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FP-180 Water Motor AFFF Proportioner First Article Procedure and Evaluation

C.R. FULPER, R.L. GIPE, C.L. WHITEHURST, R.E. BURNS,*
R.J. OUELLETTE* AND C.W. SEIGMANN*

Navy Technology Center for Safety and Survivability
Chemistry Division

**Hughes Associates, Inc.*
Wheaton, MD 20902

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12 PERSONAL AUTHOR(S) Fulper, C.R., Gipe, R.L., Whitehurst, C.L., Burns,* R.E., Ouellette,* R.J., and Seigmann,* C.W.

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Tests were conducted to evaluate the performance of two FP-180 water motor proportioners under a revised First Article Test Procedure. The procedure consists of a three part evaluation: an initial performance test, 200 hour endurance test and a final performance test. ~~Results~~ from testing show that: (1) synthetic seawater and AFFF should be used for the 200 hour endurance test instead of fresh water, (2) the 200 hour endurance test should be run in 8 hour intervals, (3) for the 200 endurance test, the pump unit should be modified to allow for recirculation of the water and AFFF into storage tanks, (4) the 2 min., 95 gpm flow test should be dropped and replaced with a performance curve , (5) the minimum AFFF concentration after the 200 hour endurance test be reduced to 4% to allow for wear, (6) for the performance curve tests, fresh water should be substituted for both the synthetic seawater and AFFF and (7) the lower AFFF concentration value between the two hose positions at a given nominal flow rate should be used in determining whether the unit is within the specified AFFF concentration range. A revised First Article Test Procedure is included in this report.

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FP-180 WATER MOTOR AFFF PROPORTIONER FIRST ARTICLE TEST PROCEDURE AND EVALUATION

OBJECTIVE

The objective of this project was to evaluate a proposed FP-180 Water Motor Proportioner First Article Test Procedure developed by Ships Parts Control Center (SPCC) [1]. The purpose of the evaluation was to:

- o verify that the proposed test procedure provides an accurate evaluation of the performance of the FP-180 water motor proportioner; and
- o define any additional modifications to the test procedure resulting from this evaluation.

BACKGROUND

A Fire Fighting Assistance Team (FFAT) was established in the early 1970's to visit aircraft carriers and check the readiness of their fire suppression systems which include the FP-180 water motor proportioner. The FFAT's reports, covering the period 1973-82, show that 378 units were tested with 64 failures, a failure rate of 17 percent. The major causes for failure in the units included low concentration proportioning, and restricted motion of a number of parts with some units being described as frozen. Mechanical problems such as frozen pumps and binding of moving parts can often be attributed to improper maintenance. The problem of low concentration proportioning however is a direct result of fluid slippage which is caused by internal wear of the rotors and side plates in the concentrate pump and water motor. As more water slips past the rotors in the water motor, a lower concentrate pump speed results. Another way of looking at this is, as slippage increases in the concentrate pump, more fluid escapes from the high pressure side of the housing back into the low pressure side. In either case, the result is a reduced volume of concentrate being discharged at a given flow.

Although internal wear is the most common cause of fluid slip, it can also be shown that slip is a function of the viscosity of a fluid being pumped. In the water motor side, only water is handled and its viscosity, for all practical purposes, is always one centistoke (cS). In the pump side,

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where concentrate is handled, the effect of viscosity can be observed. A liquid having a higher viscosity reduces the amount of slip through internal clearances such as around the faces of the rotors and past the tips of the teeth on the rotor.

When the proportioner was originally designed and put into service, protein foam concentrate was used. Typical viscosities of protein foams were in the 15 to 40 cS range and the proportioner performed well with these concentrates. The first fluorocarbon-based Aqueous Film Forming Foam (AFFF) concentrate fully suitable for use with ocean water was FC-195, which had a viscosity in the 100 to 200 cS range. Even so, it was acceptable for use in the water motor proportioners, except at low temperatures and high flow rates [2]. With succeeding AFFF formulations, the viscosity has come steadily downward to the present day range of 2 to 3 cS. The military specification (MIL-F-24385C) for AFFF concentrate requires a minimum viscosity of 2 cS at 25°C (77°F) [3].

In the protein foam era, the 3.8 cm (1-1/2 in.) hose line for foam used an air-aspirating nozzle (NPU) which flowed 227 lpm (60 gpm) at 689 kPa (100 psi). This flow rate carried over into the early AFFF era and it initially taxed the performance range of the FP-180. As most of these lines were converted to AFFF service using non air aspirating vari-nozzles, the nozzle flow ratings were increased to 360 lpm (95 gpm) and then to 473 lpm (125 gpm). Both the NPU and the vari-nozzle are still in service [4].

The FP-180's are employed in two different ways. The first application is as a portable unit which is carried to a fire scene, set up in a hose line and fed AFFF concentrate, via a pick-up tube, from 19 l (5 gal) pails also carried to the scene. The second application has the FP-180 permanently piped into a system and supplied with concentrate from a fixed 189 l (50 gal) AFFF storage tank. This set-up is used to supply hand lines, twin agent systems, and sprinkler systems. One desirable feature of the FP-180 is its variable flow capability which allows it to serve multiple nozzles without need of adjustment.

A contract was awarded to Hale Fire Pump Company in September 1980 to redesign the FP-180 [5]. The objectives were to: (a) maintain the present housing while increasing the output concentration of AFFF from 5% - 15% while maintaining water motor pressure drops in the 158 to 228 kPa (23 - 33 psi) range at flow rates of 227 to 681 lpm (60 - 180 gpm); (b) increase the life of the shaft seals and bearings; and (c) evaluate metallurgical changes. Two prototypes modified with the above mentioned design changes were tested and evaluated, and the new design was accepted in 1984 [6].

A proposed revision to the First Article Test Procedure for FP-180 foam proportioning pumps was recently submitted by SPCC for use in future testing of remanufactured units. This proposed test procedure, listed below, was forwarded to Naval Research Laboratory (NRL) for review and evaluation.

TEST PROCEDURE

The proposed revision to the First Article Test Procedure [1] calls for an initial performance test of the unit to verify that the AFFF concentration is in the range of 5% to 10%. This test is to be performed at a nominal discharge flow rate of 360 lpm (95 gpm) and a water motor intake pressure of 827 kPa (120 psi). This test is to be followed by a 200 hour endurance test.

Immediately upon completion of the 200 hour endurance test, while the unit is still hot, the initial performance test is to be repeated to determine if any significant wear has occurred. The performance test procedure is to be repeated again after the unit has cooled for 24 hours. Finally, a series of performance tests are to be performed over a range of flows from 360 to 681 lpm (95 to 180 gpm). Following a review of this procedure, the following recommendations were made by NRL:

a. It was recommended that synthetic ocean water be used in place of fresh water in the water motor for the 200 hour endurance test. Since saltwater is supplied by the firemain system on Navy ships, its use in testing would better simulate the wear conditions and the corrosive effects expected in actual use. The synthetic ocean water was to be mixed in accordance with accepted practice [7].

b. It was also recommended that the 200 hour endurance test be run in 8 hour segments instead of in a single 200 hour segment. A continuous 200 hour endurance test was considered an unrealistic scenario because the FP-180 proportioner is typically operated for short time intervals. An interrupted 200 hour endurance test, performed in 8 hour segments, better simulates actual conditions. Also, a greater degree of wear will occur to proportioner parts when subjected to temperature cycling (cold starts and hot running periods).

c. MIL SPEC 6% AFFF should be used in the concentrate pump rather than water during the 200 hour endur-ance test because AFFF can have a deteriorating effect upon pump seals.

d. A final recommendation was to modify the piping of the proportioner for the 200 hour endurance test. The modifications served two related purposes: (1) to keep the synthetic ocean water and AFFF concentrate from mixing, and (2) to allow the two fluids to be recirculated into their respective storage tanks. Without recirculation, the test procedure would consume 4.5 million liters (1.2 million gallons) of synthetic ocean water and 272.5 thousand liters (72,000 gallons) of AFFF and pose a considerable disposal problem. The required piping modifications to the FP-180 are shown in Fig. 1.

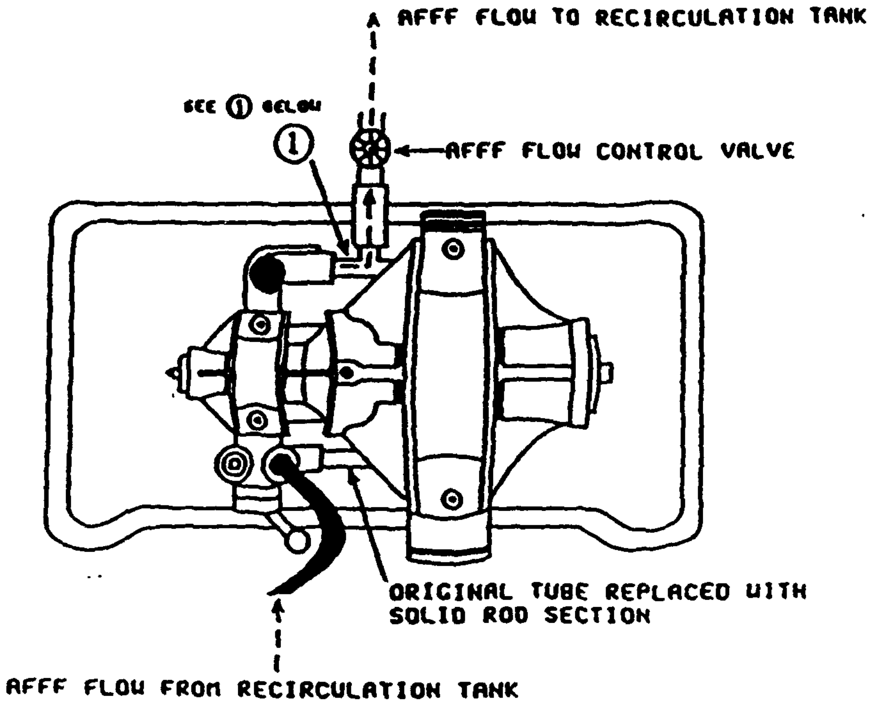
The above-mentioned changes were endorsed by the Naval Sea Systems Command, NAVSEA 56Y52 and approved by Ship Parts Control Center, Code 05114. NRL received two proportioners, serial numbers P-5473 and P-6095, from the supply system to test under this revised procedure.

Experimental Test Set-Ups

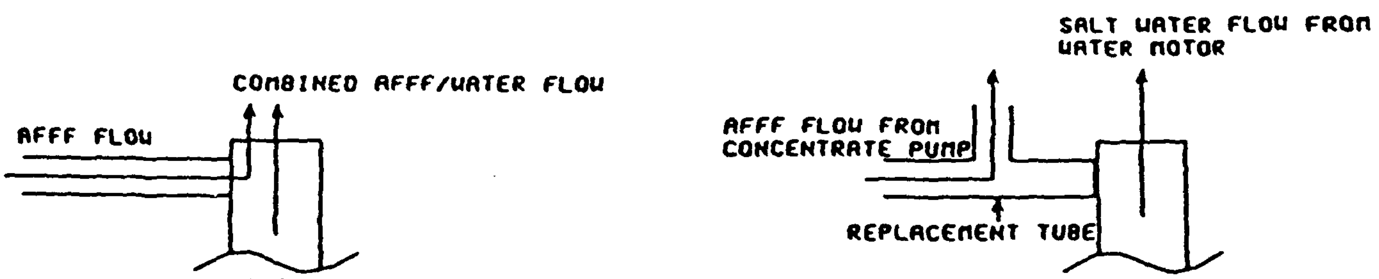
Two experimental test set-ups were used; one for the 200 hour endurance tests and one for the initial and final performance tests. These test set-ups are shown in diagram form in Fig. 2 (endurance test set-up) and Fig. 3 (performance test set-up).

Initial Performance Test Procedure

The performance curves provide a comprehensive picture of the capability of each unit to proportion AFFF concentrate properly. The units were run at a constant discharge pressure of 827 kPa (120 psi) with the flow rate varying from 360 to 681 lpm (95 gpm to 180 gpm). Fresh water was used to supply the water motor and as a substitute for AFFF in the concentrate. This practice is considered acceptable because the viscosities of the three fluids are similar [2]. The water motor and concentrate pump flow in lpm (gpm), water motor speed in RPM (revolutions per minute), and water motor intake, concentrate pump discharge, and water motor discharge pressures in kPa (psi) were measured during the performance tests. All measurements were taken at 1 min intervals on both hose positions.



① REPLACEMENT TUBE DIAGRAM



NORMAL SET UP

SET UP FOR RECIRCULATION

Fig. 1 - FP-180 water motor proportioner modifications to AFFF outlet

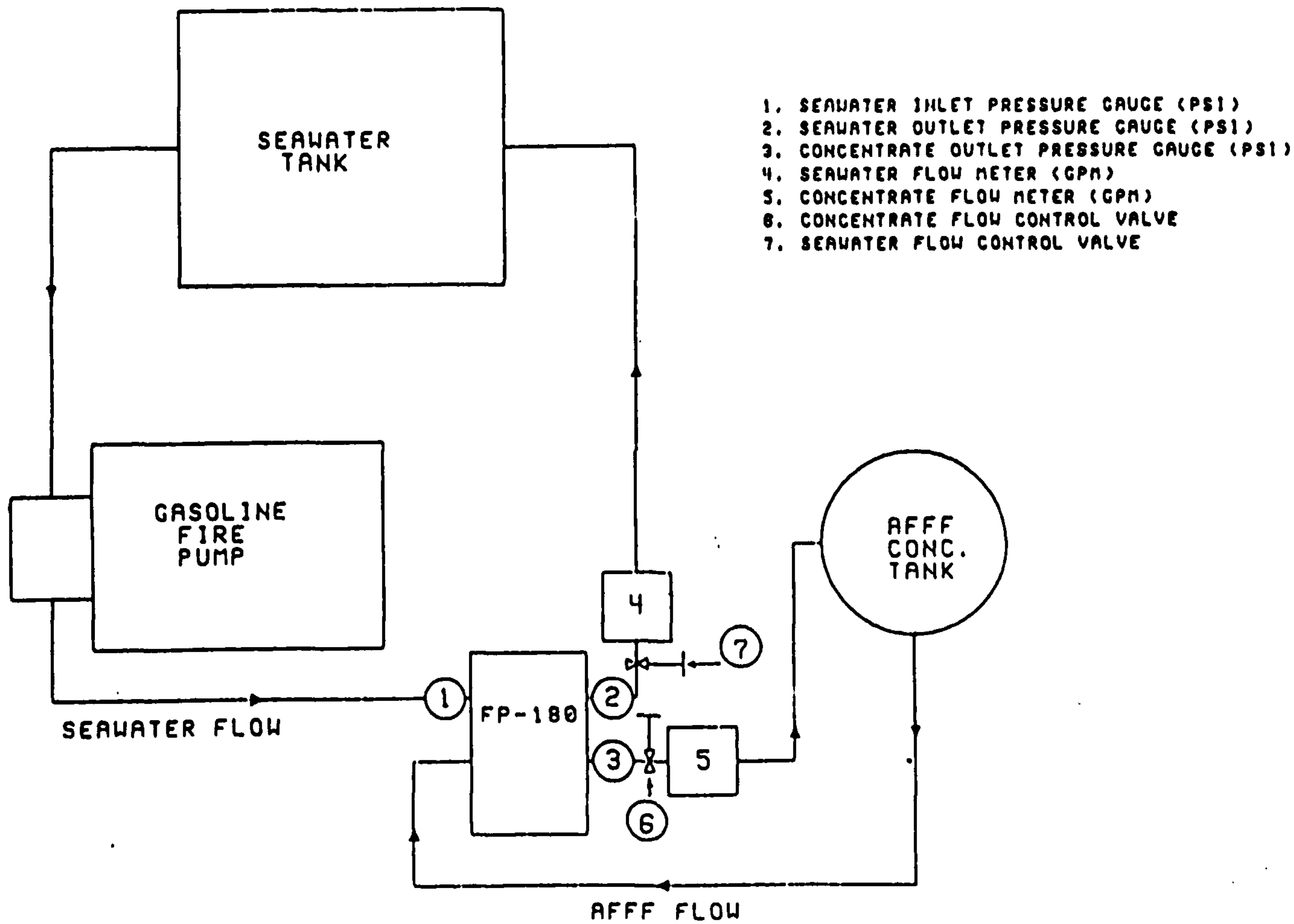


Fig. 2 - 200 hour endurance test set up for FP-180 foam proportioner

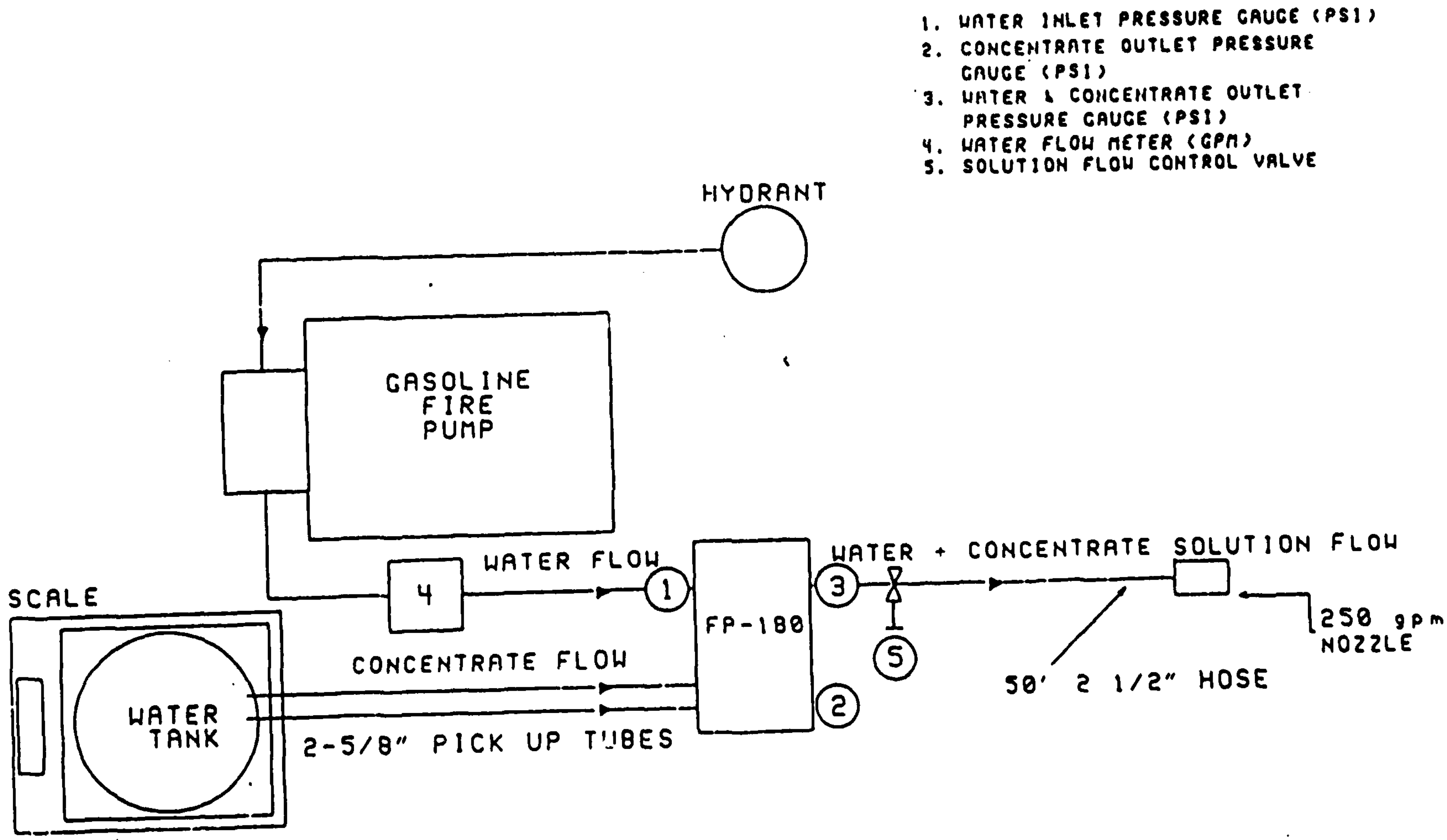


Fig. 3 - Performance test set up for FP-180 foam proportioner

200 Hour Endurance Test Procedure

A major consideration in setting up the 200 hour endurance tests was that without recirculation, the pumping of water and AFFF would require excessive amounts of both fluids. The recommended recirculation set-up used storage tanks for synthetic ocean water and AFFF concentrate which had capacities of 7570 l (2,000 gal) and 1703 l (450 gal) respectively. These recirculation procedures allow for 8 hour operation without excessive heating of the liquids. Each proportioner was modified for recirculation and operated in 8 hour intervals for a total of 200 hours. The AFFF concentrate discharge line was modified (see Fig. 1) by removing the straight injection tube and replacing it with a T-tube. The T-tube with one end blocked off, permitted recirculating the AFFF concentrate back to the AFFF concentrate storage tank, and prevented injection into the water stream. The concentrate pump priming tube (see Fig. 1) was replaced with a solid rod to prevent AFFF concentrate from back flowing into the intake side of the water motor.

Pressures were measured at the water motor's intake and discharge and at the concentrate pump discharge. In addition, the water motor speed was measured. Both the synthetic ocean water and AFFF concentrate flows were measured on the discharge side by flow meters. The AFFF flow was controlled by matching the AFFF pump discharge pressure to that of the water motor pump discharge (data from the performance tests described above showed this pressure match up to be typical for most operating conditions). All readings were taken at 1/2 hour intervals. During these tests liquid temperatures were maintained at less than 37.8°C (100°F).

Final Performance Test Procedure

Upon completion of the 200 hour endurance test, the modifications were removed from the units, and hot performance curves were developed using the initial performance test procedure. Then after cooling the unit for 24 hrs., cold performance curves were developed. These tests were performed to show any wear that might have occurred during the 200 hour endurance test period.

TEST RESULTS

The initial performance test data for each unit are shown in Tables 1a and 1b, and in Figs. 4 and 5.

Both units produced AFFF concentrations in the 5% to 10% range as required in the First Article Test Procedure. Pressure drops for both units were between 138 and 207 kPa (20 and 30 psi) and did not exceed the pressure drop limit of

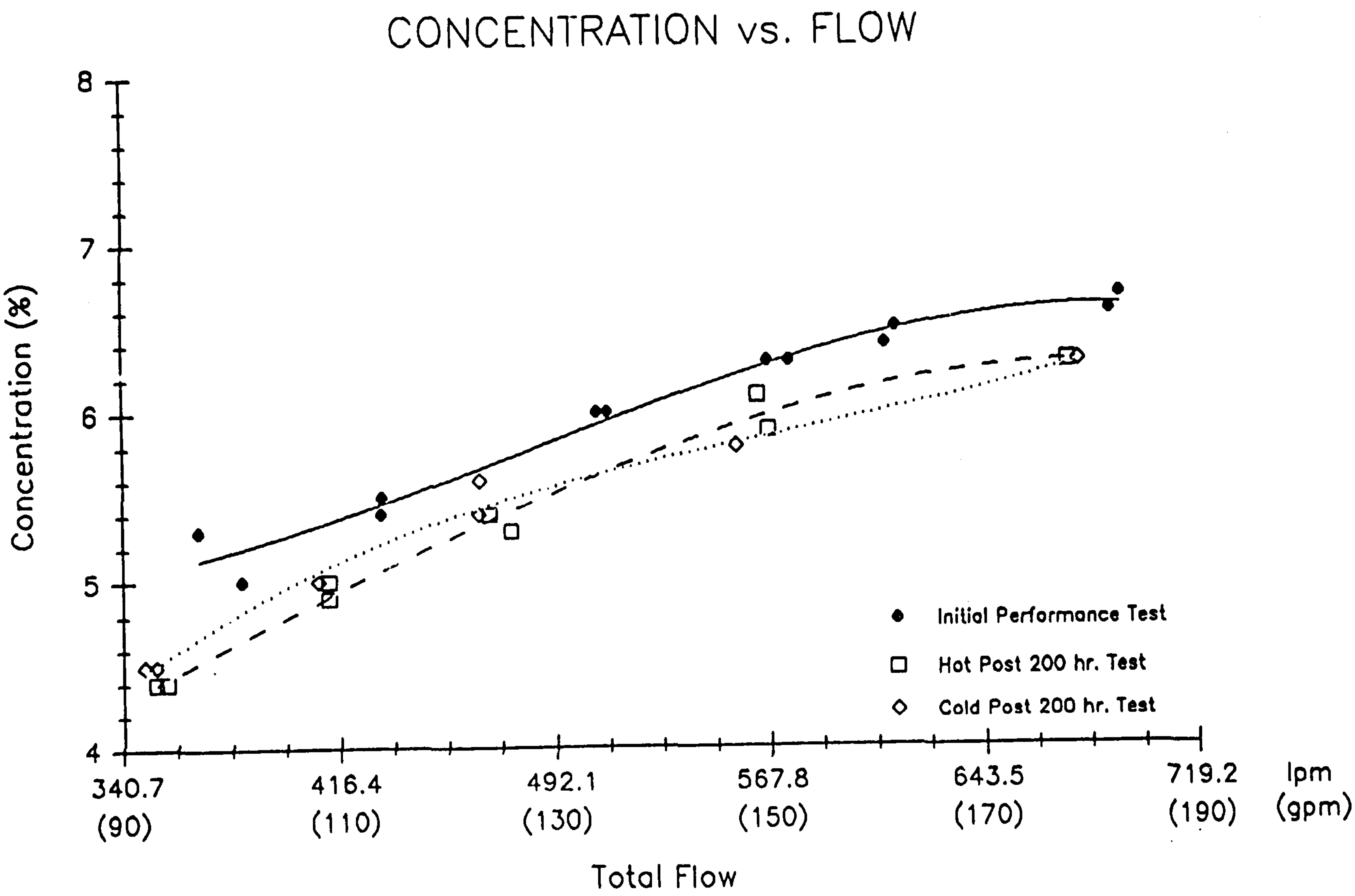


Fig. 4 — Performance Curves for Pump # P5473

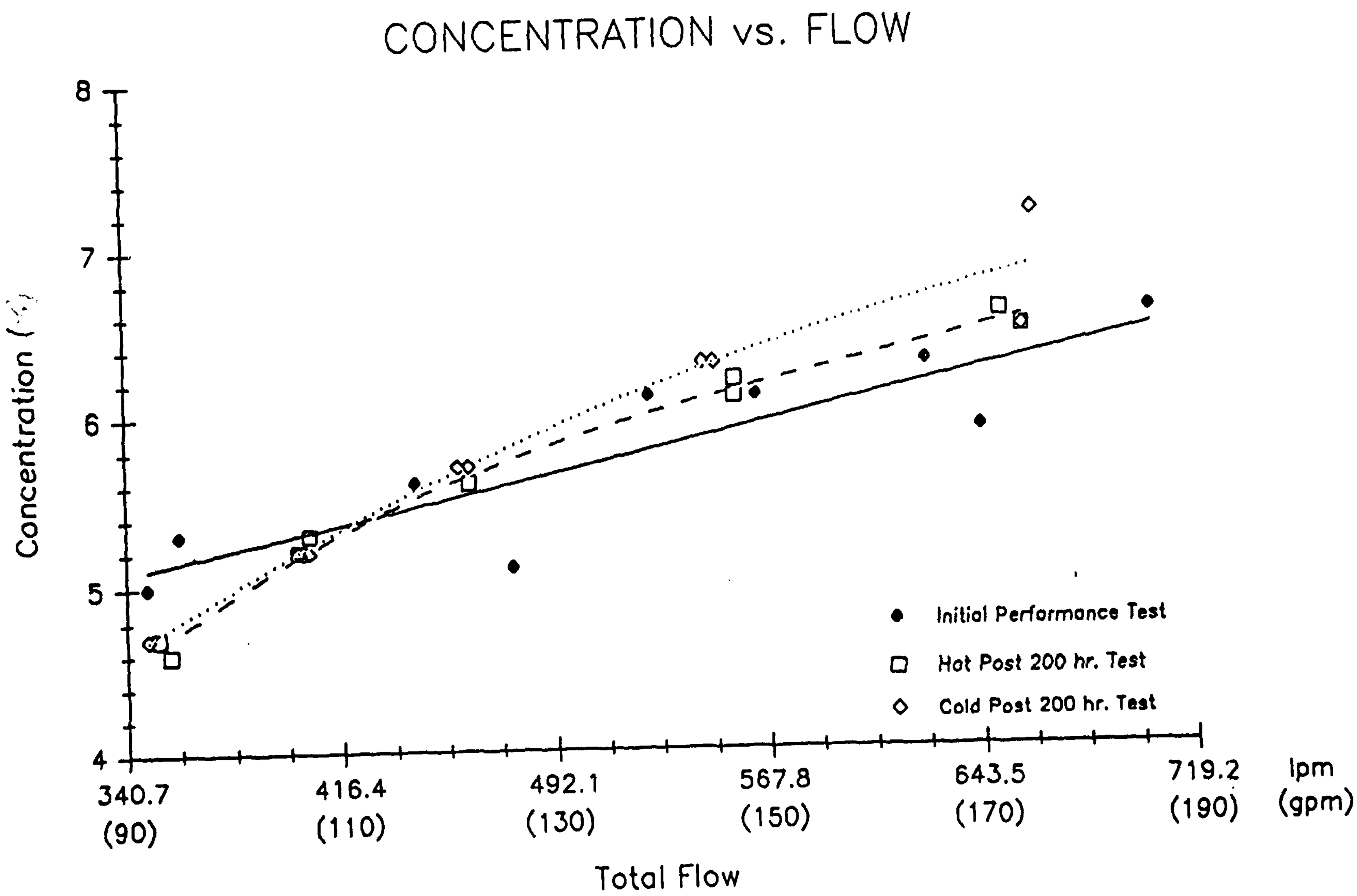


Fig. 5 – Performance Curves for Pump # P6095

241 kPa (35 psi), except at one point. This was most likely the result of the unit being new and would not be considered disqualifying since it was only a single point.

In order to confirm that fresh water can be substituted for AFFF concentrate, the performance of pump no. P6095 was checked at the nominal flow rate of 360 lpm (95 gpm) using water (Table 2) and then MILSPEC 6% AFFF concentrate (Table 3). Flow measurements were taken in 1 min intervals. The average concentration was 5.0% when using either AFFF or when using water as a simulant. This reconfirms earlier NRL work that water can be substituted for AFFF for this type of testing [8].

Table 1a - Initial Cold Performance Curve Data for P-5473 (Water substituted for AFFF)

Hose Position*	Total Fluid lpm	Total Fluid (gpm)**	Concentrate Flow lpm	Concentrate Flow (gpm)	Concentration %	Pressure Drop kPa	Pressure Drop (psi)
1	382	(101)	19.3	(5.1)	5.0	179	(26)
2	367	(97)	19.5	(5.2)	5.3	193	(28)
1	431	(114)	23.6	(6.2)	5.5	145	(21)
2	431	(114)	23.3	(6.2)	5.4	145	(21)
1	507	(134)	30.5	(8.1)	6.0	172	(25)
2	511	(135)	30.8	(8.1)	6.0	152	(22)
1	568	(150)	35.7	(9.4)	6.3	207	(30)
2	575	(152)	36.3	(9.6)	6.3	165	(24)
1	609	(161)	39.1	(10.3)	6.4	172	(25)
2	613	(162)	39.9	(10.5)	6.5	172	(25)
1	689	(182)	45.6	(12.1)	6.6	179	(26)
2	693	(183)	46.6	(12.3)	6.7	172	(25)

* Hose Position: Position of Pickup Hose Selector Valve
** Total Fluid = Water Flow + AFFF Concentrate Flow

Table 1b itial Cold Performance Curve Data for P-6095
(Water substituted for AFFF)

Hose Position	Total Fluid lpm	(gpm)	Concentrate Flow lpm	(gpm)	Concentration %	Pressure Drop kPa	(psi)
1	348	(92)	17.4	(4.6)	5.0	138	(20)
2	360	(95)	19.0	(5.0)	5.3	179	(26)
1	443	(117)	26.5	(7.0)	5.6	172	(25)
2	477	(126)	24.5	(6.5)	5.1	179	(26)
1	526	(139)	32.2	(8.5)	6.1	207	(30)
2	564	(149)	34.4	(9.1)	6.1	193	(28)
1	625	(165)	39.3	(10.4)	6.3	207	(30)
2	643	(170)	38.1	(10.1)	5.9	207	(30)
1	704	(186)	43.1	(11.4)	6.6	276	(40)
2	731	(193)	48.9	(12.9)	6.7	241	(35)

Table 2 - Two Minute 360 pm (95 gpm) Foam Flow Test for P-6095
(Water substituted for AFFF)

Hose Position	Total Fluid lpm	(gpm)	Concentrate Flow lpm	(gpm)	Concentration %	Pressure Drop kPa	(psi)
1	367	(97)	18.0	(4.8)	4.9	193	(28)
1	360	(95)	17.2	(4.6)	4.8	172	(25)
2	360	(95)	18.2	(4.8)	5.1	193	(28)
2	371	(98)	19.0	(5.0)	5.1	193	(28)

Table 3 - Two Minute 360 pm (95 gpm) Foam Flow Test for P-6095

Hose Position	Total Fluid lpm	(gpm)	Concentrate Flow lpm	(gpm)	Concentration %	Pressure Drop kPa	(psi)
1	356	(94)	18.9	(5.0)	5.3	165	(24)
1	356	(94)	19.8	(5.2)	5.6	172	(25)
2	356	(94)	18.0	(4.8)	5.1	172	(25)
2	356	(94)	18.5	(4.9)	5.2	172	(25)

Performance data at the completion of the 200 hour endurance test are shown in Tables 4a through 4d and in Figs. 4 and 5. Both units show a drop in AFFF concentration (below the 5% minimum) at 360 lpm (95 gpm) as compared with their initial performance, i.e. before the endurance tests (Tables 1a and 1b). However, it is unreasonable to expect that a unit will have the same minimum performance after 200 hours use. The change in concentration from 5.0% (Table 1a) to 4.4% (Table 4a) hot performance and 4.5% (Table 4b) cold performance for P-5473 is only a 10% degradation after 200 hours. The drop from 5.0% (Table 1b) to 4.6% (Table 4c) hot performance and 4.7% (Table 4a) for P-6095 cold performance is also within the 10% degradation range. Although some wear is indicated by the reduced concentrations and pressure drops, these values are not excessive, and with the exception of the low flows, they do fall within the criteria of the First Article Test Procedure.

Table 4a - Hot Performance Curve Data After 200 Hours for P-5473 (Water substituted for AFFF)

Hose Position Position	Total Fluid lpm	(gpm)	Concentrate Flow lpm	(gpm)	Concentration %	Pressure Drop kPa	(psi)
1	352	(93)	15.5	(4.1)	4.4	165	(24)
2	356	(94)	15.6	(4.1)	4.4	152	(22)
1	413	(109)	20.2	(5.3)	4.9	165	(24)
2	413	(109)	20.6	(5.4)	5.0	152	(22)
1	469	(124)	25.2	(6.7)	5.4	165	(24)
2	477	(126)	25.4	(6.7)	5.3	165	(24)
1	564	(149)	34.4	(9.1)	6.1	179	(26)
2	568	(150)	33.5	(8.9)	5.9	165	(24)
1	674	(178)	42.4	(11.2)	6.3	179	(26)
2	674	(178)	42.2	(11.1)	6.3	179	(26)

Table 4b - Cold Performance Curve Data After 200 Hours for P-5473 (Water substituted For AFFF)

Hose Position	Total Fluid lpm	Total Fluid (gpm)	Concentrate Flow lpm	Concentrate Flow (gpm)	Concentration %	Pressure Drop kPa	Pressure Drop (psi)
1	348	(92)	15.7	(4.1)	4.5	124	(18)
2	352	(93)	16.0	(4.2)	4.5	124	(18)
1	409	(108)	20.6	(5.4)	5.0	138	(20)
2	409	(108)	20.5	(5.4)	5.0	152	(22)
1	466	(123)	25.9	(6.9)	5.6	152	(22)
2	466	(123)	25.0	(6.6)	5.4	138	(20)
1	556	(147)	32.2	(8.5)	5.8	152	(22)
2	556	(147)	32.3	(8.5)	5.8	152	(22)
1	678	(179)	42.4	(11.2)	6.3	172	(25)
2	678	(179)	42.6	(11.3)	6.3	172	(25)

Table 4c - Hot Performance Curve Data After 200 Hours for P-6095 (Water substituted for AFFF)

Hose Position	Total Fluid lpm	Total Fluid (gpm)	Concentrate Flow lpm	Concentrate Flow (gpm)	Concentration %	Pressure Drop kPa	Pressure Drop (psi)
1	356	(94)	16.6	(4.4)	4.6	165	(24)
2	352	(93)	16.8	(4.4)	4.7	165	(24)
1	405	(107)	21.2	(5.6)	5.3	152	(22)
2	401	(106)	20.9	(5.5)	5.2	152	(22)
1	462	(122)	25.9	(6.8)	5.6	152	(22)
2	462	(122)	25.7	(6.8)	5.6	152	(22)
1	556	(147)	34.3	(9.1)	6.2	152	(22)
2	556	(147)	34.1	(9.0)	6.1	152	(22)
1	659	(174)	42.6	(11.3)	6.5	165	(24)
2	651	(172)	43.0	(11.4)	6.6	165	(24)

Table 4d - Cold Performance Curve Data After 200 Hours for P-6095 (Water substituted for AFFF)

Hose Position	Total Fluid lpm	(gpm)	Concentrate Flow lpm	(gpm)	Concentration %	Pressure Drop kPa	(psi)
1	348	(92)	16.5	(4.4)	4.7	152	(22)
2	348	(92)	16.3	(4.3)	4.7	152	(22)
1	405	(107)	21.0	(5.6)	5.2	152	(22)
2	401	(106)	20.9	(5.5)	5.2	152	(22)
1	458	(121)	26.2	(6.9)	5.7	159	(23)
2	462	(122)	26.3	(7.0)	5.7	159	(23)
1	549	(145)	34.4	(9.1)	6.3	165	(24)
2	545	(144)	34.1	(9.0)	6.3	165	(24)
1	662	(175)	47.7	(12.6)	7.2	193	(28)
2	659	(174)	43.1	(11.4)	6.5	186	(27)

CONCLUSIONS

1. FP-180 Foam Proportioners P-6095 and P-5473 when tested against the revised First Article Test Procedure did meet all of the performance criteria before the 200 hour endurance test. Specifically the units maintained an AFFF concentration between 5% to 10% and a pressure drop of less than 241 kPa (35 psi).

2. Neither unit met the minimum criterion of 5% for AFFF concentration at the lowest nominal flow rate of 360 lpm (95 gpm) after completion of the 200 hour endurance test, but both were within 10% of the minimum. This is not unexpected after 200 hours of wear. Both units met the minimum 5% AFFF requirement at 409 lpm (108 gpm) and above.

3. The use of a recirculation system during the endurance test is an appropriate method of testing the units without the expense of large quantities of synthetic ocean water and AFFF concentrate.

4. Water was verified as a suitable substitute for AFFF in the performance test procedure.

5. Performance of the pump after the 200 hour endurance test did not vary significantly between the hot performance test and the cold test one day later.

6. Developing a performance curve instead of a single performance point provides a better overall evaluation of the system performance.

RECOMMENDATIONS

The following recommendations are made in addition to those listed on pages 5 - 6:

1. The 2 min, 360 lpm (95 gpm) flow test should be dropped and replaced with a performance curve test which would assure acceptable performance not only at one point, but rather over the full range of possible flows. The flows used for the performance curve should be 360, 473, 568 and 681 lpm (95, 125, 150, and 180 gpm). Also, the water motor intake pressure should be held at a constant 1034 kPa (150 psi) for all flows, as this is a fairly representative firemain pressure.

2. Three sets of performance curves should be developed, one before the 200 hour endurance test, with the unit warmed up for 5 min, and two after the endurance test, one being with the unit hot and one with it cold.

3. The minimum AFFF concentration after the 200 hour endurance test should be reduced to 4% to allow for wear.

4. For the performance curve tests, fresh water should be substituted for both the synthetic ocean water and AFFF.

5. The lower AFFF concentration value between the two hose positions at a given nominal flow rate should be used in determining whether the manufacturer's unit is within the specified AFFF concentration range.

6. The revised First Article Test Procedure as modified in Appendix 1 should be submitted to NAVSEASYSCOM for acceptance.

REFERENCES

1. R. Wise, "First Article Test Procedure for FP-180 Foam Proportioner," SPCC, 08 September 1986.

2. R.L. Gipe and H.B. Peterson, "Proportioning Characteristics of Aqueous Film Forming Foam Concentrates," NRL Report 7437, July 1972.

3. Military Specification, "Fire Extinguishing Agent, Aqueous Film Forming Foam (AFFF) Liquid Concentrate, for Fresh and Sea Water," MIL-F-24385C, 12 March 1981.

4. Military Specification "Nozzles, Fire Hose, Combination Aqueous Film Forming Foam, Water Spray, Adjustable Pattern (Shipboard Use)," MIL-N-24408A(SH), 24 October 1986.

5. K. Broitman, "FP-180-Model 12 MPD Foam Proportioner Improvement Program," Hale Fire Co., ER-1605A prepared for Naval Research Laboratory under contract no. N00173-80-0414, May 17, 1980.

6. R.L. Gipe, C.L. Whitehurst, H.B. Peterson, E.J. Jablonski, and R.E. Burns, "Evaluation of a Redesigned FP-180 Water Motor Proportioner for AFFF," NRL Memorandum Report 5339, 18 June 1984.

7. American Society of Testing and Materials (ASTM), ASTM D-1141, Substitute Ocean Water.

8. R.L. Gipe, C.L. Whitehurst, R.E. Burns and S. Cater, "Balance Pressure Proportioner System," NRL Memorandum Report 5802, 12 June 1986.

APPENDIX

MODIFIED REVISION OF FIRST ARTICLE TEST PROCEDURE FOR FP-180 FOAM PROPORTIONERS

1. Three FP-180 foam proportioners from each contractor shall be delivered to Naval Research Laboratory for testing in accordance with this procedure.

2. Two basic types of tests shall be performed on each unit, a performance test and a 200 hour endurance test. These tests shall be performed in the sequence listed below.

3. An initial performance test shall be conducted as follows:

   (a) The unit shall be warmed up by flowing 360 lpm (95 gpm) at a water motor inlet pressure of 1034 kPa (150 psi) for 5 min. The hose selector valve may be in either position. Fresh water shall be used to supply both the water motor and the AFFF concentrate pump. The unit shall be set up so that the concentrate pump is drawing from draft through the pickup tubes.

   (b) The unit shall then be run at a constant water motor inlet pressure of 1034 kPa (150 psi) for nominal flow rates of 360, 473, 568, and 681 lpm (95, 125, 150, and 180 gpm). The unit shall be operated for 2 min on each hose position at each flow rate. Water motor intake and discharge pressures, water motor speed, and water motor and concentrate pump flow rates shall be recorded at 30 second intervals. A weight drop method shall be used to calculate concentrate pump flows.

   (c) The unit shall maintain a concentration of 5% to 10% and a maximum pressure drop across the water motor of 241 kPa (35 psi).

4. The 200 hour endurance test shall consist of:

   (a) The unit shall be modified so that the water motor and concentrate pump sides are separated. These modifications will also allow for recirculation of the two fluids. Diagrams of the two pieces of tubing necessary for making these modifications are available from the Naval Research Laboratory.